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Toward Locust Management: Challenges and Technological opportunities, Sikaunzwe Zambia.

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***Abstract* - Locust invasions have proved to be a threat to the world's food security and livelihood. Governments in locust infested areas in Africa have adopted various early warning strategies aimed at preventing and eliminating the impact of both African Migratory Locusts and Red Locusts. These measures include community sensitisation, use of eLocust3 early warning system and spraying of affected areas using recommended pesticides. Management of locusts in the study area, Sikaunzwe Agriculture Camp in Zambia, is however faced with unique challenges. The research was focused on exploring challenges faced by the ministry of agriculture in managing the spread of locust invasions using the existing early warning strategies. Focus Group Discussion (FGD) method was used in the study and NVivo 11, a qualitative data analysis software, was used to analyse the data based on thematic coding framework. The following challenges were acknowledged; failure to identify correct locust species, limited field staff and inaccessibility of infested areas. The proposed technology solutions to the above challenges include the use of machine learning, low cost drones, geospatial technology and Internet of Things.**

Keywords: Focus Group Discussion, eLocust3, African Migratory Locust, Red Locust, Machine Learning, Internet of Things

I. Introduction

Locust invasions have proved to be a threat to the world's food security and livelihood [1],[2]. Under favourable climatic conditions, locusts in solitary phase regroup to form swarms, a state often referred to as gregarious phase. Prevention of locust damage to crops and grazing land becomes difficult at this stage. More resources and international collaborations are needed to fight locust outbreaks. Governments in locust infested areas in Africa have adopted various early warning strategies aimed at preventing and eliminating the impact of locusts. The measures are more effective when the locusts are in solitary phase. Various early warning strategies are being employed to prevent locusts from forming swarms. Community sensitizations have proved effective over the years since the community is ever on guard against any traces of locust invasion. Other strategies include an effective and efficient early warning system developed by the Food and Agricultural Organisation (FAO). During years of outbreaks characterized by huge locust populations, affected countries also incorporate the use of recommended pesticides.

Fig. 1. Solitary African Migratory Locust (AML)

The government of the republic of Zambia through the ministry of Agriculture and Livestock, in conjunction with other stakeholders such as FAO, have instituted measures to cab the spread of Locusts in the study area, Sikaunzwe Agricultural Camp even during times when there is no outbreak [3]. Sikaunzwe Agricultural Camp is based in Southern Province of Zambia in Kazungula District of Livingstone town. The area was largely affected by the African Migratory Locust (AML) in December 2020 see figure 1 above. Crops and grazing fields were severely affected [4]. The loss of crops led farmers to resort to the sale of animals cheaply in an effort to meet the household needs such as food and education for the children, among other basic requirements [4]. The area is also largely vulnerable to Red locust outbreaks. Concerted efforts by local and international organisations were crucial for effective management of locust invasion in the study area [5]. The research was focused on exploring challenges faced by the Ministry of Agriculture and Livestock in managing the spread of locust invasions using the existing early warning strategies as well as suggest technological opportunities available to counter the challenges. Focus Group Discussion method was proposed for the study based on the thematic framework and the use of NVivo for qualitative data coding and data analysis in an effort to determine the challenges of managing locust invasions.

II. Literature review

The food and Agriculture Organisation (FAO) with the help of other partners have advanced the use of technology to manage locust invasion across the globe. Among its major tasks include locust prevention measures and use of early warning strategies. Innovations in the management of desert locusts has for instance resulted in the development of field tools such as eLocust3, GPS, internet phones and the drone technology. eLocust3 is used to monitor the occurrence of locusts in areas that are prone to locust invasions. It has been in use for data entry and real time transmission of data since 2015. It’s a great tool that has the capacity to observe environmental conditions such as vegetation, rainfall and soil moisture. Each country’s National Locust Control Centre (NLCC) receives real time data through satellite from the field before submitting it to the Desert Locust Information Service (DLIS) (Showler, 2021). DLIS receives information from NLCC through email and upon data checking and verification, it is imported into Schistocerca Warning and Management System (SWARMS) [6]. SWARMS is a global Geographical Information System (GIS) which is custom designed by FAO headquarters in Rome. It is used to analyse data and gives output in form of rainfall patterns, vegetation distribution using high resolution satellite imagery, locust development and other past records [7]. Apart from the initial purpose of data collection or logging and outright transmission, eLocust3 has an advantage of providing remote location imagery data using remote sensing technology [7]. Access to remote sensing has enabled field workers to target the changing vegetation when searching for the possibility of locust invasion.

eLocust3 has been improved upon since its inception and more features have been added. These include the development of a smartphone application which incorporates the chat facility for information sharing among users and the ability to capture videos in the field. The drone, developed by FAO in partnership with HiMap Foundation of Spain, is a unique, customized and fixed wing drone which has enabled easy navigation. It is used to map green vegetation for possible locust invasion in far places encompassing up to a maximum of 80KM [6]. The data from the tools identified above is consolidated by a Data Cube for further analysis and display in various formats. In addition to eLocust3 and the drone, FAO has also introduced a digital control tower called the Earth Ranger. The Earth Ranger in an innovation that enables the visual consolidation of locust efforts being conducted across the globe such as location of planes involved in spraying and location of locusts.

The data collection tools that are provided by FAO such as eLocust3 and the Drone are not equipped with locust image identification facilities. This poses a challenge since images of similar grasshoppers are at times confused with locusts. According to [8], there is a proliferation in the use of Artificial Intelligence (AI) to monitor pests in Smart Agriculture. Artificial intelligence refers to the machine’s ability to think and act like human beings. AI is also instrumental in image recognition but lack of a well-established locust monitoring system in southern Africa has hampered its full exploitation [9] [10], [11] and [12]. Allocation of enough resources to innovations that enhance the capability of early warning systems can play a significant role in locust management [13] [14].

According to [15], locusts’ impact on agriculture has been in existence for decades and humans have, as a way of protection, devised preventive measures. [16] attribute countries’ unpreparedness as one of locust management challenges. Furthermore, long years of no invasions lead to relaxed responses, diminished stock of essential equipment and lack of skilled manpower whenever there is an outbreak. Other challenges include bad terrain and security instability in certain areas. Lack of coordinated locust control efforts especially when more than one country is involved poses a challenge to smooth locust management.

[16] reiterates the challenges associated with the availability and application of insecticides during desert locust invasion and this is normally influenced by cost and safety. To avert the situation, Pakistan, other countries in the region and the international organisations embarked on both land and air spraying efforts. [17] furthermore echoes the seriousness of the locust pests to agriculture globally.

III. Methodology

The Focus Group Discussion (FGD) was conducted in December, 2021 in a quiet outdoor area on a round table in Kazungula District in Zambia. According to [18] focus group method refers to a “research technique that collects data through group interaction on a topic determined by the researcher”. The participants were all male with an average age of over 40 years comprising three locust experts with an average of 16 years of locust management experience from the Ministry of Agriculture and Livestock, the Entomology Professor, Computer Science Doctor and a PhD student from the University of Zambia. Most of the participants were selected from southern province of Zambia and were familiar with each other, a trait that ensured that contributions were held in a comfortable manner. The FGD was converged after the participants' visit to the Sikaunzwe plains where locusts breed from.

The FGD marked the first stage of a big study, "A framework for an early warning system for the management of the spread of locust invasion in Zambia; based on Artificial Intelligence Technologies". The first stage was designed to engage staff on the challenges faced in the management of locust invasion using existing early warning strategies. During the FGD, the participants were tasked to respond to questions corresponding to the challenges of managing locust invasion in the study area. Participants were briefed about the objective of the study at the beginning of the FGD by the moderator and they were also clearly informed that results from the discussion will be a guide to the next objective of the research.

The research team had a series of meetings to develop the FGD topic guide. The FDG not only discussed questions related to the overall research project but also looked at specific questions that elicited views from participants on the locust management challenges. The FGD questions included but were not limited to participants experience with locusts, views on the best way to control locust invasion, preparedness of the ministry of agriculture during and after the recent invasion, views on the use of eLocust3 system as an early warning system and views on other ICT tools to mitigate the impact of locusts on community livelihood. The focus group was organized by a PhD student who also moderated the discussion. The end of the FGD was characterize by a brief summary of the major issues that were identified. Participants were also given a change to add comments or ask a few questions. The FGD lasted for approximately three hours and all deliberations were recorded.

Data Coding and analysis

All audio files that were collected were not only transcribed verbatim but each transcript was thoroughly studied and coded with a view of highlighting participant views on challenges of managing locust invasion and available technological opportunities. To protect participant confidentiality, all participant data was made anonymous. NVivo 11, a qualitative data analysis software was used for data management, data coding and data analysis. The words and codes linked similar statements from each participant in the NVivo database. Pattern exploration and conceptualization of the final findings was made possible using the search function. Thematic coding framework was applied in the study processes from open to a well-focused coding. For a topic to be added as a theme, more than one participant should have commented on it during the FGD.

IV. Results and discussion

The FGD analysis yielded the following three themes;

1. Staff's failure to identify correct locust species
2. Limited field staff
3. Inaccessibility to affected areas.

1. Failure to identify correct locust species

The FGD identified the challenge of staff failure to identify correct species of locusts. The challenge was also reiterated by [10] and [19] in which they expressed the inefficiencies of manual locust identification of various locust instars and accuracy monitory of locusts respectively. This has at times led to alarming information being sent to Locust Control Center that is managed by FAO. Asked on the capability of eLocust3 Application to resolve this challenge, the FGD reported that the early warning system doesn't have a feature that can help them automatically recognise the type of locust when in doubt.

Fig. 2. Gregarious AML

2. Limited field staff

There is lack of enough field personnel to monitor any traces of invasion. Each agricultural camp has only one trained locust expert.

3. Inaccessibility of infested areas

The accessibility to the affected areas when the plains are flooded is physically impossible since the grass is too tall. The locally made canoes cannot also easily navigate through the flooded plains.

Proposed Technological Solution

The research team proposed the design of a Mobile Application that will enable an automatic identification of pests using Artificial Intelligence (AI) based on a custom-made dataset of both AML and Red Locust. This proposal is also supported by [10] who employed AI to automatically identify migratory locust species in East Asia. Other researchers who have incorporated AI in grasshopper research include [20]. The FGD also considered the possibility of engaging FAO concerning the installation of the AI Application on eLocust3 installed Tablets.

The project is proposing an early warning system for the management of the spread of Locust invasion based on AI and other emerging technologies such as IoT, Geospatial, and cloud computing technologies. A sticky trap, fitted with a light bulb will enable effective catching of targeted insects. Each sticky trap will be energy independent using a battery that will be charged by solar energy. The Raspberry Pi 4B microcomputer, connected with a Pi camera and sensors, will form part of the perception layer of the proposed IoT node. The camera will automatically take images of the captured pests daily. To enhance collection of local weather, Soil moisture, wind direction, rainfall, temperature and humidity sensors shall be utilised. The local weather data will be of help in identifying the favourable conditions that influence the proliferation of both Africa Migratory Locust (AML) and Red locust.

To enable the smooth gathering of data, an integrated GPRS and 3G/4G connectivity will be incorporated and a Global Positioning System (GPS), serially connected to the Raspberry Pi, will provide an automatic positioning awareness and geospatial data of each sticky trap. The captured information will be sent to the web browser for easy data visualization.

This approach is supported by [21] who developed an IoT solution to monitor agricultural activities. The machine learning model will be part of the Trap. This will ultimately reduce the number of field visits to the area.

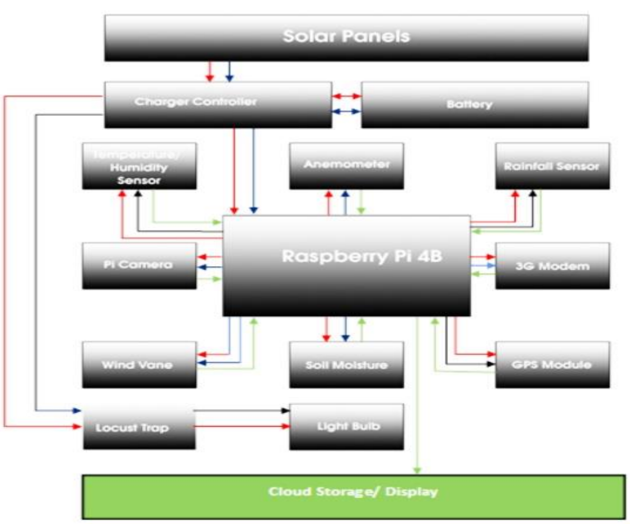

Fig. 3. Locust Trap

This presents an opportunity of using low cost AI powered Drones to capture areas that cannot be easily accessed. The use of drones in agriculture is also supported by [22]. Furthermore, [23] employed drones to identify locust concentration in areas that are prone to locust invasion.

V. Conclusion

The research was focused on exploring challenges faced by the ministry of agriculture in managing the spread of locust invasions using the existing early warning strategies. Focus Group Discussion (FGD) methodology, based on the thematic coding framework was used in the study. The FGD lasted for approximately three hours and this demonstrated the participants willingness to find a lasting solution to the challenges that they are facing. NVivo 11 qualitative data coding and analysis software was used. The FGD identified three themes summarised as staff's failure to identify correct locust species, limited field staff and inaccessibility to affected areas. The proposed technological solutions to the above challenges have been presented and summarised. Data concerning the availability of locusts and other environmental data will be effortlessly disseminated to stakeholders. Automated and precise data collection coupled with the enhanced monitoring accuracy and powerful analytical application will significantly increase the quality of locust management efforts.

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